5.0 MASS BALANCE ACTIVITIES

5.1 Annual Mass Balance of Recycled Uranium

Recycled uranium was the product of the ICPP. With the exception of two small shipments, all of the recycled uranium at ICPP was the product of the uranium reprocessing operation. The two small shipments were returns of ICPP product from facilities that had received it from ICPP. One shipment was a denitrator product prepared at Y-12 from liquid ICPP product to produce the granular, high-enriched material needed to start up the ICPP denitrator. The second shipment was a partial return of material shipped to PNNL for criticality experiments but was not required for their needs.

The bulk of the material shipped from ICPP, went to Y-12. Most of the rest was sent to Portsmouth. The annual shipments are shown in Table XV which includes "most probable" estimates of the contaminants in the final product.

5.2 Annual Mass Balance for Plutonium

The plutonium contaminants were based on information from the Egli report which indicated that the alpha concentration was less than the alpha specification. In the period from 1953 to 1977 the alpha content varied between 22 and 61% of Y-12s informal specification. Since 1977 the alpha content has been 31% of the specification.

By utilizing those facts and using a conservative alpha specification which says that the alpha content can not exceed 5000 dpm transuranic alpha per gram of uranium, estimates for the alpha content can be made. The annual mass balance for shipments for plutonium is shown in Table XV.

5.3 Annual Mass Balance for Neptunium

The neptunium content is also a contributor to the alpha specification. If it is assumed that it behaves in the same way that plutonium does in the extraction system, an estimate for the neptunium content can be obtained. These values are shown in Table XV.

5.4 Annual Mass Balance for Technetium-99

The technetium-99 contamination was determined by using the ORIGEN2 calculated data for dissolver product. This was converted to final product values using the beta decontamination factor which was general for all beta emitters. These values are shown in Table X. Because the predominant beta emitter was ruthenium-106, this estimate for technetium-99 is considered to be higher than actual values.

Table #: XV

Recycled Uranium Shipments

Shipping Site Name: Idaho Chemical Processing Plant

Year	Receiving Site	Chemical Form	% U-235	Quantity of U (Kg)	Range of Estimated/Measured Constituents					Comments
					ppb Pu-239	ppb Pu-238	ppm Np-237	Percent U-236	pbb Tc-99	
1953	Y-12	$UO_2(NO_3)$		310.983	0.12	0.03	1.2	13.0	1.1	
1954	Y-12	UN		* 279.824	0.12	0.03	1.2	13.0	1.1	
1955	Rocky Flats	UN		219.093	0.12	0.03	1.2	13.0	1.1	
1955	Y-12	UN		742.669	0.12	0.0.3	1.2	13.0	1.1	
1956	Y-12	UN		1,122.452	0.12	0.03	1.2	13.0	1.1	
1957	Y-12	UN		611.851	0.12	0.03	1.2	13.0	1.1	
1958	Y-12	UN		2,683.680	0.12	0.03	1.2	13.0	1.1	
1959	Y-12	UN		1,763.087	0.12	0.03	1.2	13.0	1.1	
1960	Y-12	UN		579.649	0.12	0.03	1.2	13.0	1.1	
1961	-	-		-	-	-	-	-	-	
1962	Y-12	UN		775.823	0.12	0.03	1.2	13.0	1.1	
1963	Y-12	UN		770.678	0.12	0.03	1.2	13.0	1.1	
1964	Y-12	UN		421.818	0.12	0.03	1.2	13.0	1.1	
1965	Y-12	UN		812.790	0.02	0.12	1.6	20.0	1.8	
1966	Y-12	UN		595.477	0.12	0.03	1.2	13.0	1.1	
1967	-	-		-	-	-	-	-	-	
1968	Y-12	UN		821.403	2.1	0.03	1.2	13.0	1.1	

* The Y-12 copy of the 741 lists 942.3 grams of "scrap" on 741 CPI-CYT 16 on March 17, 1954. We showed on both lists that there was 9,423 grams of product shipped. Since this is listed as scrap rather than product, it has been removed from the quantity shipped.

Table #: XV **Recycled Uranium Shipments**

Shipping Site Name: Idaho Chemical Processing Plant

Year	Receiving Site	Chemical Form	% U-235	Quantity of U (Kg)	Range of Estimated/Measured Constituents					Comments
					ppb Pu-239	ppb Pu-238	ppm Np-237	Percent U-236	ppb Tc-99	
1969	-	-	-	-	-	-	-	-	-	
1970	Y-12	UN		527.383	0.02	0.12		20.0	1.8	
1971	Y-12	UO_3		1,654.977	0.12	0.03	1.2	13.0	1.1	
1972	Y-12	UO_3		434.476	0.02	0.12		20.0	1.8	
1973	Portsmouth	UO_3		1,374.895	35.3	0.03	0.031	0.34	0.018	2% Burnup EBR-II
1973	Y-12	UO_3		552.835	0.12	0.03	1.2	13.0	1.1	
1974	Y-12	UO_3		381.339	0.12	0.03	1.2	13.0	1.1	
1975	Y-12	UO_3		898.009	0.12	0.03	1.2	13.0	1.1	
1975	Portsmouth	UO_3		1,402.663	35.3	0.03	0.031	0.34	0.018	2% Burnup EBR-II
1976	Y-12	UO_3		519.582	0.02	0.12	1.6	20.0	1.8	
1976	Portsmouth	UO_3		1,298.210	35.3	0.03	0.031	0.34	0.018	2% Burnup EBR-II
1977	Y-12	UO_3		976.177	0.12	0.03	1.2	13.0	1.1	
1978	PNNL	UO_3		47.010	0.12	0.03	1.2	13.0	1.1	
1978	Y-12	UO_3		526.966	35.3	0.03	0.031	0.34	0.018	
1979	Y-12	UO_3		534.754	0.02	0.12	1.6	20.0	1.8	
1980	-	-		-	-	-	-	-	-	
1981	Y-12	UO_3		904.422	0.02	0.12	1.6	20.0	1.8	
1982	Y-12	UO_3		1,102.135	35.3	0.03	0.031	0.34	0.018	

Table #: XV

Recycled Uranium Shipments

Shipping Site Name: Idaho Chemical Processing Plant

Year	Receiving Site	Chemical Form	% U-235	Quantity of U (Kg)	Range of Estimated/Measured Constituents					Comments
					ppb Pu-239	ppb Pu-238	ppm Np-237	Percent U-236	ppb Tc-99	
1983	Y-12	UO_3		517.913	0.12	0.03	1.2	13.0	1.1	
1984	Y-12	UO_3		*2,868.215	-	-	-	-	-	Lightly Irradiated ROVER
1984	LASL	UN		* 167.606	-	-	-	-	-	Lightly Irradiated custom
1985	-	-		-	-	-	-	-	-	
1986	Y-12	UO_3		955.115	0.12	0.03	1.2	13.0	1.1	
1987	-	-		-	-					
1988	-	-		-	-					
1989	-	-		-	-					
1990	-	-		-	-					
1991	-	-		-	-					
1992	-	-		-	-					
1993	-	-		-	-					
1994	Y-12	UO_3		* 116.496	-	-	-	-	-	Lightly Irradiated custom
1995	-	-		-	-					
1996	-	-		-	-					
1997	-	-								
1998	Y-12	UO_3		0.424	0.02	0.12	1.6	20.0	1.8	

* The material in these three shipments were lightly irradiated or unirradiated custom processing materials. Most of the lightly irradiated material was ROVER product.

5.5 Annual Mass Balance for Other Constituents

The U-236 values shown in Table XV were values actually measured on composited samples of dissolver product during the late 1980s. These values are the maximum values reported for uranium-236 and were determined by mass spectrometry.

Uranium-236 was included because it results in significant radiation exposures in aged material due to the presence of decay product, uranium-232 and its daughters, particularly thallium-208 which is short-lived with a high-energy (2.6 Mev) gamma emission.

5.6 Potential for Worker Exposure from Recycled Uranium

As the calculations in Section 2.4 indicated most of the effective dose equivalent exposures would be due to the uranium radionuclides (see Table III). Uranium-234, Because of its short half-life (2.45×10^{-5} years) compared to the half-lives (10^{-7} to 10^{-9} years) of the other uranium isotopes in ICPP product, uranium-234 is often the dose limiting radionuclide. Uranium-234 is significantly concentrated by the gaseous diffusion plants and then increased slightly more in a reactor through n, 2n reactions with uranium-235. Throughout the history of ICPP, the risk of exposure to radionuclides in final product was based on the uranium isotopes rather than the actinide or fission product radionuclide. As can be seen in Table III, the plutonium isotopes are at least an order of magnitude lower risk than the highest risk uranium isotope. High-enriched, high-burnup fuels have high concentrations of uranium-234, -235, and -236 which are the limiting isotopes in handling ICPP product.

The bioassay programs would pick up internal exposures to uranium. The uranium that was frequently observed was usually natural uranium from the environment and was not considered to be a problem at that level. The presence of uranium-234 or uranium-236 or of higher enrichments of uranium-235 would result in follow up to determine the extent of the dose and the source. In general, because of the monitoring for uranium isotopes, the risk of exposure to other constituents in ICPP product, was small.

5.7 Potential for Environmental Contamination from Recycled Uranium.

There was no risk of environmental contamination from ICPP recycled uranium product.

6.0 RESULTS AND CONCLUSIONS

6.1 Explanation of Mass Flow Paths and Contaminant Levels

Material shipped from the Idaho Chemical Processing Plant was sent to Y-12 and to Portsmouth for future processing. Smaller quantities were sent to Rocky Flats, Hanford and Los Alamos for criticality studies. This material was subsequently either returned to ICPP for cleanup or sent directly to Y-12 for processing prior to being shipped to Savannah River. Some is still believed to be in inventory at the